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IMPROVEMENT OF BATCH PREPARATION AND FEEDING FOR GLASS FURNACES

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The factors affecting the maintenance of stable batch quality when batch is loaded into glass furnaces after being transported from a sectional shop over a long distance are analyzed. The deficiencies arising during batch preparation and transport to a glass furnace are analyzed. A new method of loading batch into a glass furnace is proposed on the basis of the analysis; this method makes it possible to support optimal moisture content and uniformity of batch prior to loading into the furnace. The new method of loading batch has been tested in a glass furnace at "Salavatsteklo" JSC.

Key words: batch moisture content, batch temperature, batch uniformity, batch quality, additional wetting of batch, batch loading method.

The first step of our study of optimizing physical-chemical processes for preparing glass batch and evaluating the effect of its moisture content on the effectiveness of the glass-making process [1] made it possible to determine that the optimal moisture content of the batch at all stages of batch preparation from the mixer in the sectional shop to loading into a glass furnace is of definite value for obtaining a uniform batch and maintaining its uniformity. It was established that it is important to maintain the batch temperature at the level 35 – 40°C before the batch is loaded into a glass furnace.

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The main factors that determine the prescribed batch temperature level and correspondingly influence the change in the moisture content during batch preparation have been identified [1]:

temperature of the raw materials, including cullet;

temperature of the wetting agent during wetting of the batch components being mixed;

ambient conditions and path length during transport of the batch to the glass furnace.

To account of the effect of the environment the enclosure along the entire transport path of the batch was heated and the optimal temperatures of the surrounding environment were determined: 25 – 30°C (Fig. 1). The batch temperature under these conditions decreased during transport by 2 – 3°C,

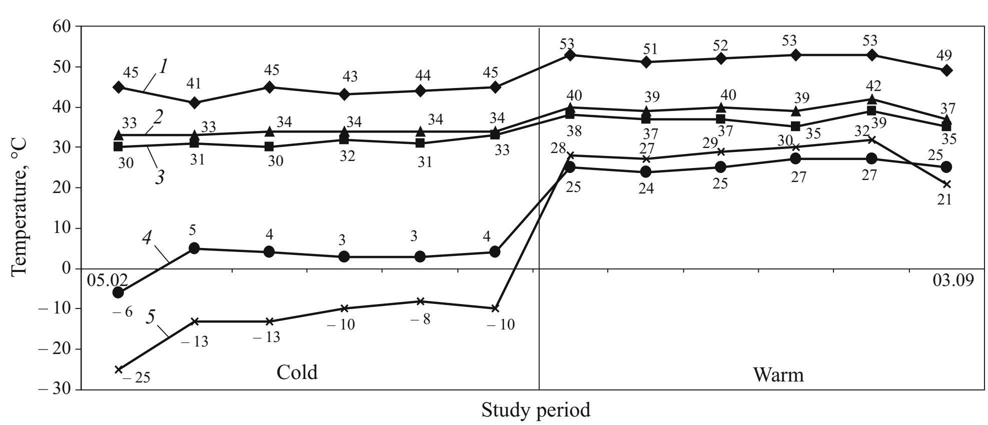

Fig. 1. Batch temperature in the cold and warm time periods. Batch temperature: after the sectional shop *1*; after the mixer *2*; before the mixer *3*; temperature: in the batch transport enclosure *4*; surrounding environment *5*.

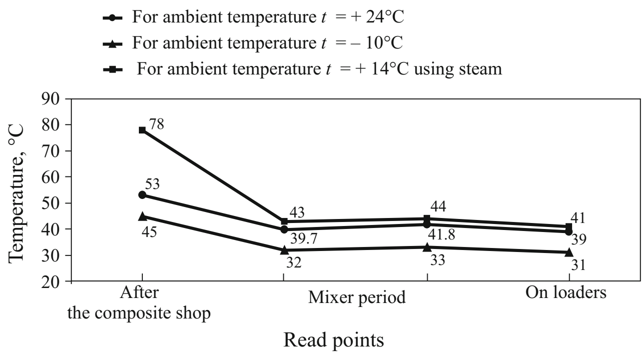

Fig. 2. Variation of the batch temperature along the batch transport path under different temperature conditions.

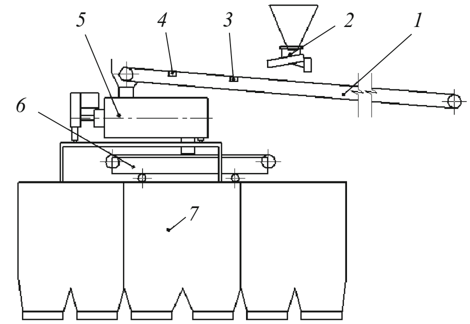

Fig. 3. Method for loading batch into a glassmaking furnace.

and when the ambient temperature decreased to 3 – 8°C the batch temperature along the conveyer decreased by 10°C.

The raw materials temperature during batch preparation using hot water to 70°C for wetting was inadequate to raise the batch temperature to the prescribed level. For this reason, it was proposed that steam be used as an additional wetting agent. Figure 2 shows that variation of the batch temperature along the transport path with different temperature conditions.

Analysis showed that even for batch temperature 35 – 40°C the batch quality also depends on a number of other important factors during loading into the glass furnace:

– time and type of batch transport from the mixer to the loading site of the glass furnace;

– moisture content in the batch;

– grain-size composition of the raw materials used for the batch.

Of course, the quality of batch prepared in the dispensing-mixing division is a determining factor for making molten glass. However, the prescribed batch parameters and the parameters attained before the batch is loaded into the glass furnace must be preserved. Maintaining stable moisture content in the batch in the range 4.5 – 5.0% on the loaders for high-capacity furnaces is no easy problem, especially for sheet glass. In the first place it is difficult to obtain moisture content 5% or more in the batch mixer and then to maintain this value along the path to the batch loaders of the glass furnace, after all the moisture losses from the batch during transport and intermediate storage reach 1% [1].

The batch moisture content at the loaders affects the acquisition of the optimal cartogram of the surface of the molten glass and the effectiveness of heat transfer during the process of making molten glass. The grain-size composition of the cullet and the method used to feed cullet together with the batch into the glass furnace are also important factors here [2].

No less important a problem is maintaining the quality of the mixed batched as it is loaded into the batch dispensing hoppers. The investigations show that the top batch marker in the hoppers must be constant. However, in practice the hoppers can be filled to a level below 1/3 their height. Batch stratification intensifies when a reversible conveyer is used for loading the hoppers [3].

Analysis of the deficiencies indicated above, which arise during the preparation and transport of the batch to the glass furnace, suggested a new way to load batch into a glass furnace.

The method is implemented as follows. In the sectional shop the batch components are dispensed following a set prescription, mixed in a mixer, and wetted with water (steam) to the optimal level for obtaining good uniformity and satisfying the moisture content conditions 3.7 – 4% for subsequent transport. Next, a belt conveyer *1* transports the batch to the loading container of the glass furnace (Fig. 3). The cullet is weighed and fed by a vibrating feeder *2* onto the batch layer. The first sensor *3* placed on the batch-feeding conveyer generates a signal indicating the presence of batch on the conveyer and actuates the mixer. When the batch passes by the second sensor *4* a signal opening a valve allowing hot water to flow into the mixer is generated. The water flows through a pressure regulator and is squirted into the mixing chamber. For this, an additional strain gauge for weighing the batch and a controller for controlling the water pump are placed on the conveyer. From the belt conveyer the batch flows through a chute into the mixer *5*. Mixed and wetted, the batch advances to the outlet opening and then onto the reversible conveyer *6*.

Thus before being fed into the furnace the batch is loaded into a continuous mixer. In the process cullet in a prescribed amount 5 – 25% and a wetting agent to reach the optimal moisture content for the glassmaking conditions are added, and additionally mixed to obtain a batch and cullet mixture with the required quality. The mixer is placed directly above the hoppers of the batch loaders *7*.

The continuous mixer is a horizontal cylindrical mixing tank, near whose walls displaced plunger-type blades rotate near the shaft. The size and geometric shape of the blades are designed and the blades aligned with respect to one another in a manner so that they throw the bulk material from the bottom layer into the empty mixing space and lift it away from the wall of the drum against the centrifugal force. When the Froude number reaches a value > 1 the mechanically produced vortex layer with constant coverage of the entire vo-

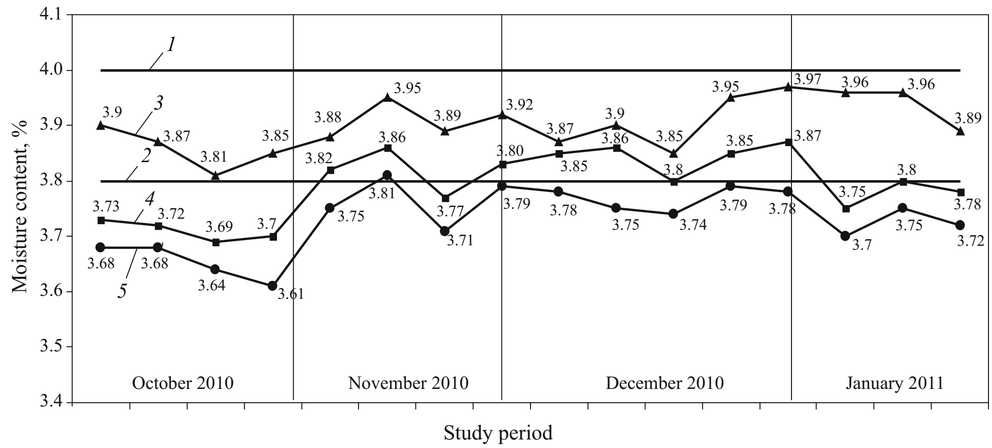

Fig. 4. Variation of the moisture content of the batch before additional moistening in the mixer: *1*, *2*) prescribed maximum and minimum moisture content of batch in a composite shop; *3*) in the composite shop; *4*) after re-pouring; 5) in front of the mixer.

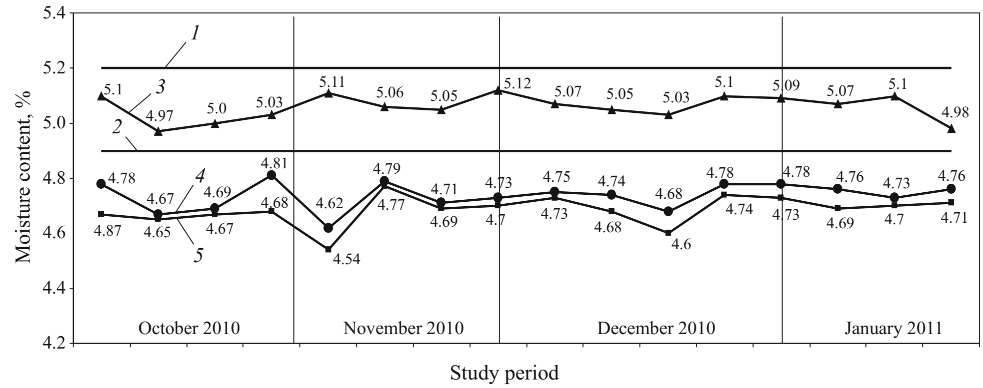

Fig. 5. Variation of the moisture content of the batch after additional mixing and wetting in the mixer: *1*, *2*) prescribed maximum and minimum batch moisture content after the mixer; batch moisture content: *3*) after the mixer; *4*, *5*) in the left- and right-hand loaders, respectively.

lume of mixed material gives intense mixing even with large throughput and short standing time. Such a method of mixing the material eliminates crushing (pulverization) of particles between the wall of the mixer and the blade.

The proposed method of loading the batch into a glass furnace was tested with the batch moisture reaching 5.2% after the mixer and batch moisture content on the tables of the loaders 4.5 – 4.8%.

An analysis of the variation of the moisture content of the batch before additional moistening in the mixer is shown in Fig. 4.

During the tests the problem of reaching batch moisture content ± 5% before loading into the furnace was posed. The limiting values of the moisture content in the batch were set at 4.9 – 5.2%. The results of the variation of the batch moisture content after additional mixing and wetting in the mixer are shown in Fig. 5. Hot water with temperature 70°C was used as the wetting agent. The additional amount of water required to support the prescribed batch moisture content and the quantity of water entering the glassmaking furnace together with the batch were determined (Fig. 6).

Work to determine the effect of cullet on batch quality and the uniformity of the cullet distribution in a batch layer

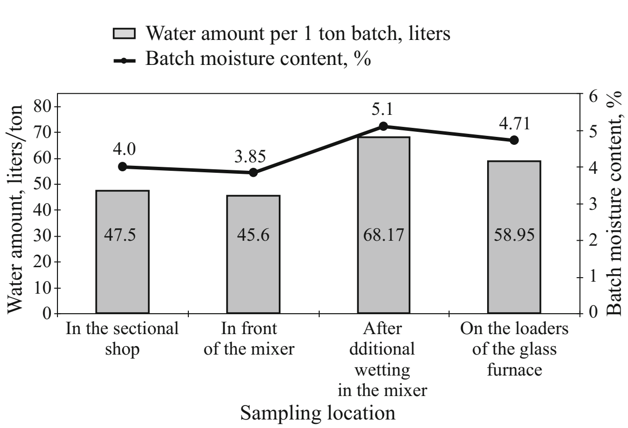

Fig. 6. Variation of the moisture content of the batch as a function of the amount of water for wetting.

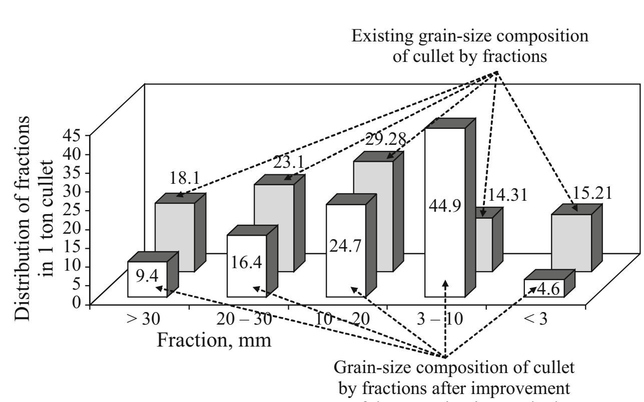

Fig. 7. Grain-size composition of cullet by fractions.

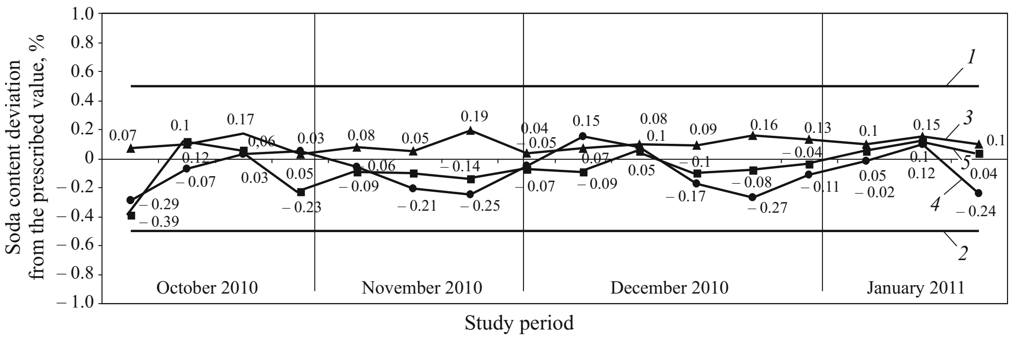

Fig. 8. Variation of the soda content in batch: soda content deviations: *1*, *2*) maximum (+ 0.5) and minimum (– 0.5%); *3*) in a sectional shop; *4*) in front of mixer; *5*) after mixer.

when mixed together with the batch was also performed. The results of the studies of the optimization of the grain-size composition of the cullet are presented in Fig. 7. The best results were obtained with the cullet fractions 10 – 20 and 3 – 10 mm with content 70 – 75%. At this level the cullet content in the batch was maintained from 9.0 to 15.0%.

A method was chosen to determine batch uniformity from the magnitude of the admissible deviations of the soda content in the batch.

The results (Fig. 8) show that batch has the following parameters after additional mixing:

– temperature 40°C;

– moisture content 4.9 – 5.2%;

– uniformity with admissible deviations by components — components deviating by 0 – 0.5% from prescribed values — should be at least 90%; uniformity with 0.5 – 0.8% deviations should be no more than 10%.

Thus, the proposed method of loading batch into a glass furnace makes it possible to avoid almost all drawbacks of the existing method:

– additional wetting and mixing occur directly above the site where batch is loaded into the glass furnace;

– any decrease of the uniformity of the batch arising as batch is transported over long distances is prevented;

– batch moisture losses during transport and intermediate storage in hoppers are compensated;

– the batch moisture is optimal (≥ 5.0%) before loading into the furnace without decreasing the batch uniformity and without degrading the operating conditions of the transport equipment;

– the decrease of the batch temperature during transport is compensated by its additional heating in the mixer, as a result of which the batch temperature is 35 – 45°C before loading into the furnace;

– dust generation on the loading container and removal of batch components into the furnace regenerators are considerably diminished.

The method presented for loading batch into a glass furnace has passed tests a float-line at the “Salavatsteklo” JSC.

As a result of the tests a batch moisture content 5.0 – 5.2% after the mixer together with high batch quality — more than 90% first class — was obtained. Batch with moisture content 4.7 – 4.8% entered the glass furnace. Ultimately, this has a positive effect on the glassmaking process in the furnace – – the heat transfer between the flame, batch, and molten glass improved.

This method makes it possible to increase the batch moisture content at loading into a furnace to 5.5 – 6.0% or more. In this case water becomes one of the active components of the batch. However, the processes involved in making molten glass in a high-capacity furnace, especially a sheet-glass furnace, with batch moisture content more than 5% have not been studied much.

At the same time the effect of the moisture content of batch must be studied in a comprehensive manner, taking account of the grain-size distribution of the raw materials, the interaction of the water, soda and sulfate, SO_3 and CO_2 gases, bi- and trivalent iron oxides and other physical-chemical processes in which water participates, as well as the temperature regime for making glass and the oxidation-reduction state of the medium.

This is the direction that our future work will take.

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